

# TISA Working Group Report

**CERES TISA Sublead:** D. Doelling

**TISA:** A. Gopalan, E. Kizer, C. Nguyen, M. Nordeen, M. Sun, J. Wilkins, F. Wrenn

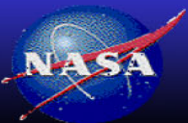
**GEO calibration:** R. Bhatt, C. Haney, B. Scarino

**Sub-setter:** C. Mitrescu, P. Mlynchzak, C. Chu, E. Heckert

*2018 Earth Radiation Budget Workshop*

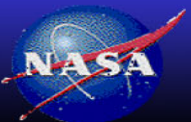
*National Center for Atmospheric Research, NCAR Mesa Lab*

*Boulder, CO, September 10-13, 2018*



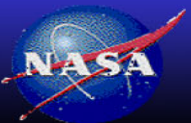
# Outline

- Goal to summarize the CERES flux and cloud impacts between input versions
- MODIS C5/C6/C6.1 calibration improvements
- MODIS to VIIRS scaling factors
- Aerosol quality between C5/C6
- GEO processing improvements
- Ed4 and Ed4.1 TOA flux and cloud comparisons
- Conclusions



# MODIS C5/C6/C6.1 CALIBRATION AND IMPROVEMENTS

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[https://satcorps.larc.nasa.gov/cgi-bin/site/showdoc?  
mnemonic=SAT\\_CALIB\\_USER](https://satcorps.larc.nasa.gov/cgi-bin/site/showdoc?mnemonic=SAT_CALIB_USER)

Granule used to determine scaling factors

**Aqua-MODIS Band 1 (0.6465- $\mu\text{m}$ ) Radiance ( $\text{Wm}^{-2}\text{sr}^{-1}\mu\text{m}^{-1}$ )**

Free Linear:  $y = 1.0018x + 0.000703$   
 Forced Linear [0]:  $y = 1.0019x + 0$   
 Polynomial:  $y = 0.0011x^2 + 1.0007x + 0.01703$   
 Num: 687155

Collection 6.1

Collection 6

Free Linear  
 Forced Linear [0]  
 Polynomial



# C5 to C6 and C6 to C6.1 MODIS channel scaling factors

Visible %	Terra C5->C6	Terra C6->C6.1	Aqua C5->C6	Aqua C6->C6.1
B3 0.47μm	1.2%*	0.0	-0.8^	0.3
B1 0.65μm	1.4^	0.0	-0.4^	0.2
B2 0.86μm	-1.5^	0.0	-0.7^	0.2
B5 1.24μm	-1.7	0.0	0.0	0.0
B6 1.61μm	0.0	0.0	0.0	0.0
B7 2.11μm	-0.5	0.0	0.0	0.0

IR (BT) %	Terra C5->C6	Terra C6->C6.1	Aqua C5->C6	Aqua C6->C6.1
B20 3.8μm	#	0.0	0.0	0.0
B27 6.7μm	*	‡	0.2*	0.0
B29 8.6μm	&	‡	0.0	0.0
B31 11μm	0.0	0.0	0.1	0.0
B32 12μm	0.0	0.0	0.1	0.0
B33 13μm	0.0	0.0	0.0	0.0

\*Detector striping

^ VZA dependency

#cold temperature saturation, seasonal adjustments

&cold temperature range C6=180K and C5=200K

‡correction for cross talk after anomaly

- Next few slides will show examples of these issues

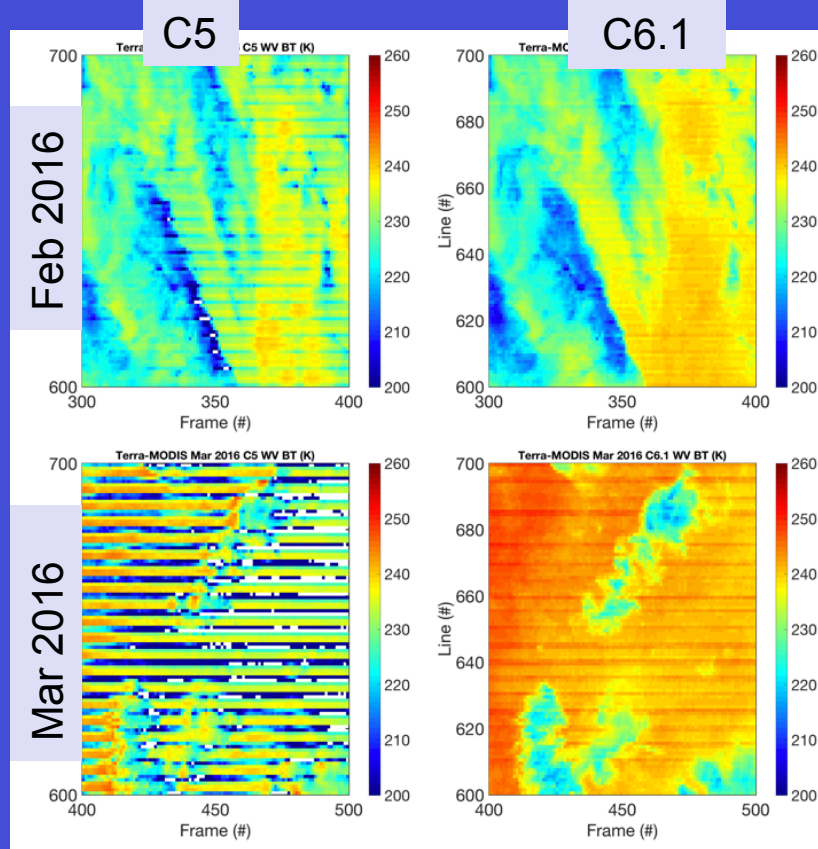


# Terra-MODIS WV, C6.1 improvements

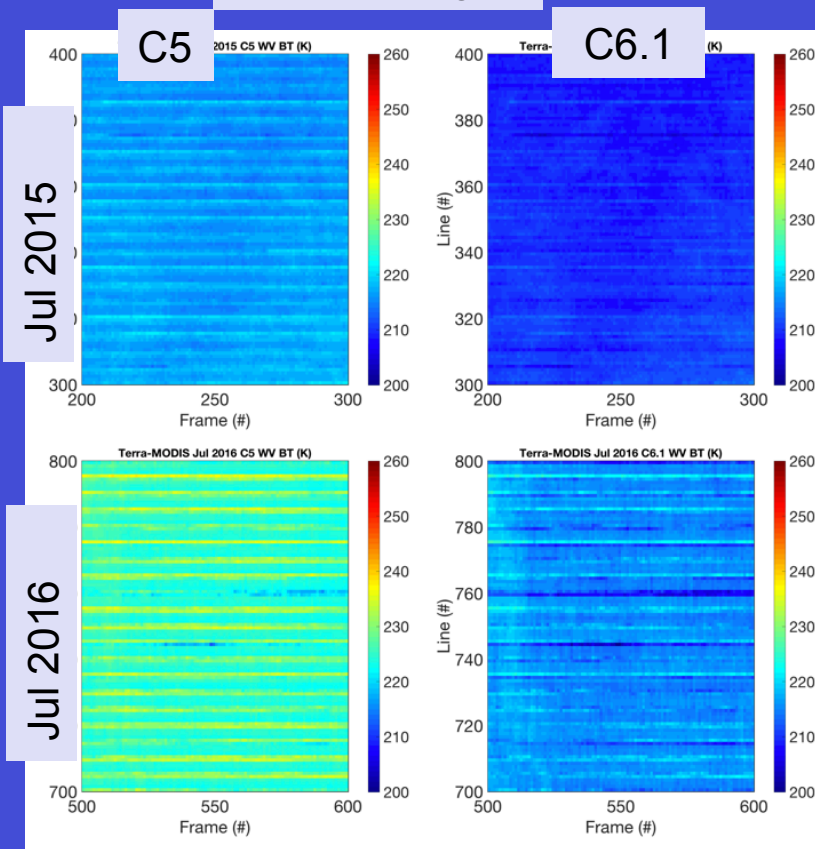
Tropical Day

Antarctic Night

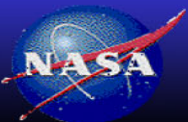
Before Terra  
anomaly



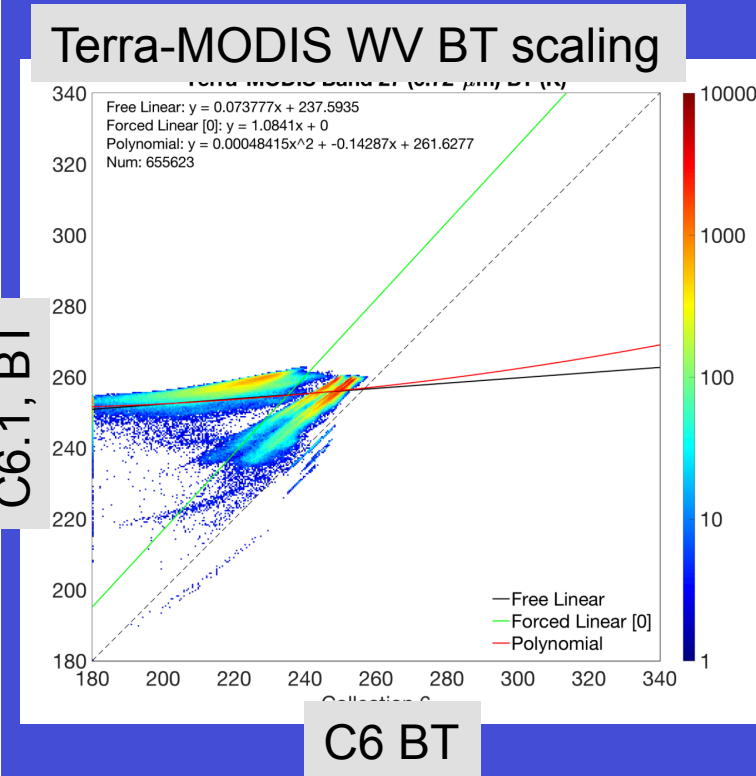
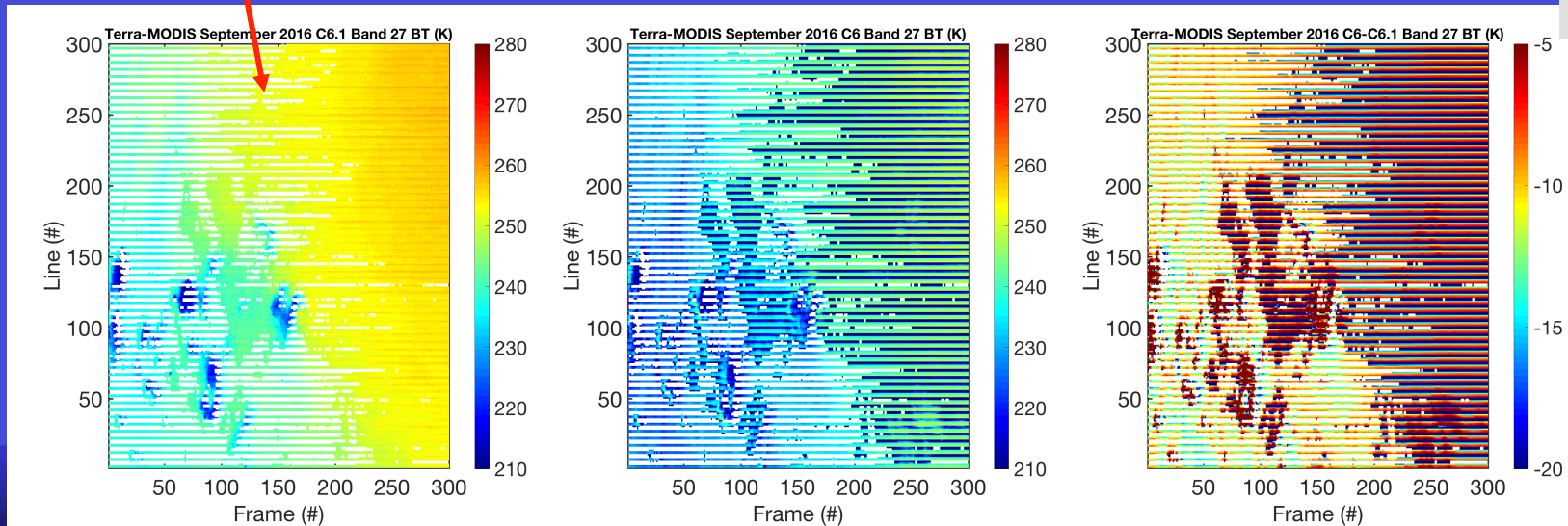
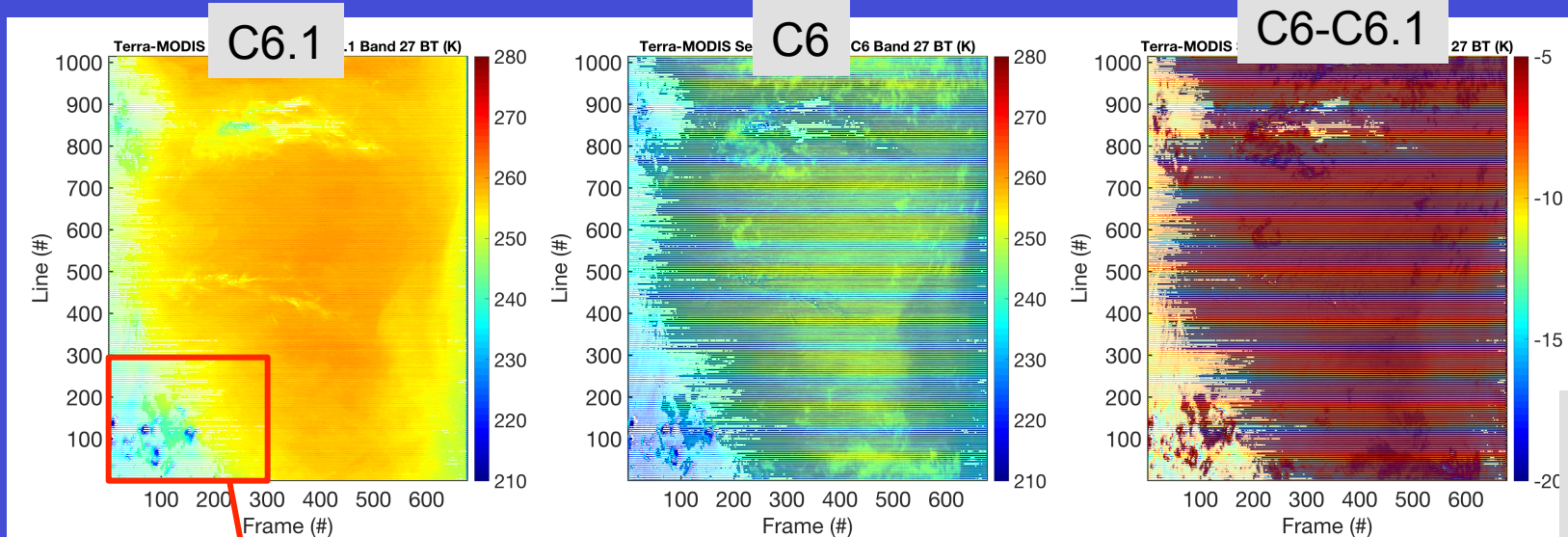
After Terra  
anomaly



- Terra-MODIS WV cross-talk after spacecraft anomaly showed up to 30K detector to detector striping



# Terra-MODIS WV C6-C6.1 scaling, Sept 2016





# Terra-MODIS 8.6μm, scaling

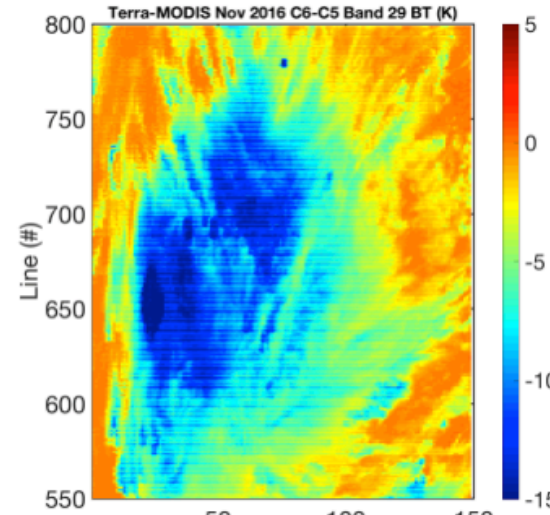
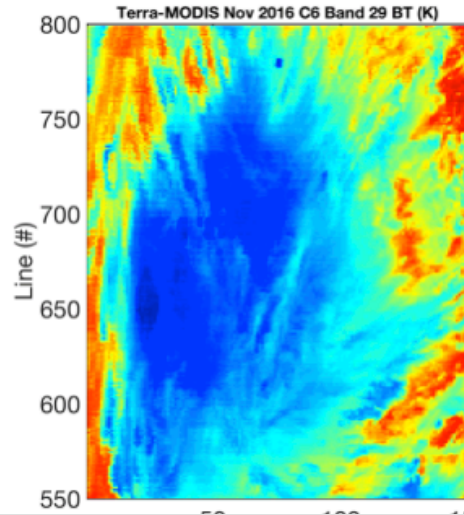
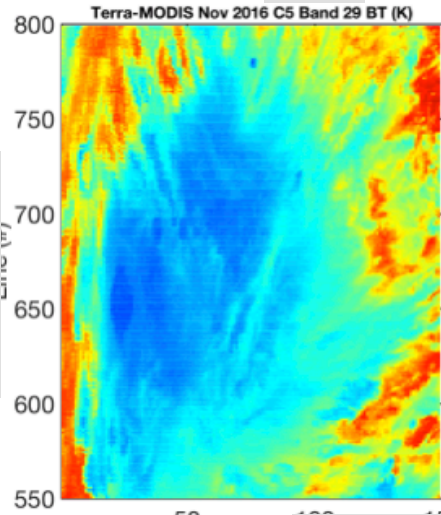
C5

C6

C6-C5

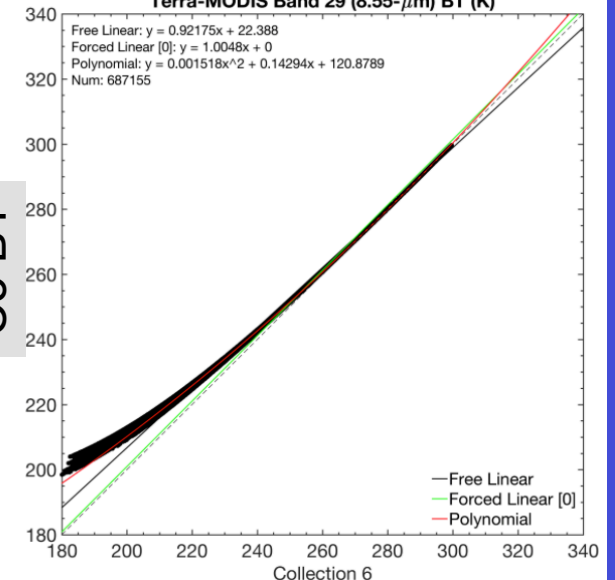
C6 to C5 scaling

Nov 2016



Frame (#) MOD02SS1.S2016307.0010.006.2016307143521.hdf

C5 BT



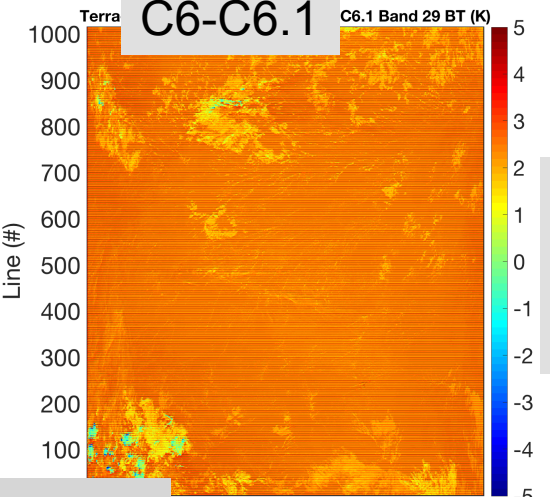
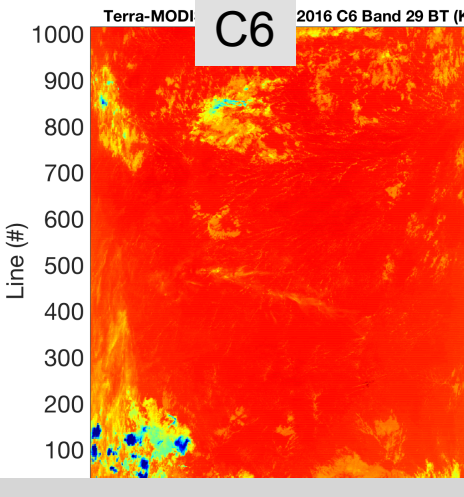
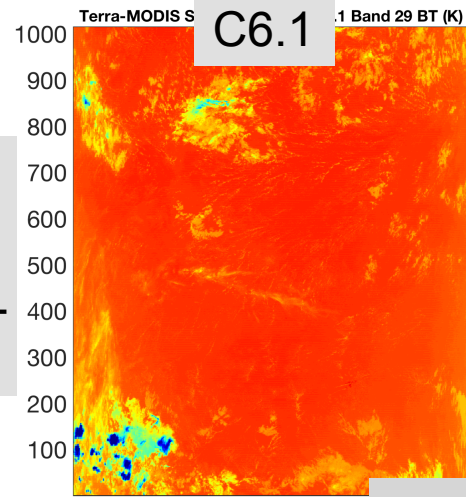
Sept 2016

C6.1

C6

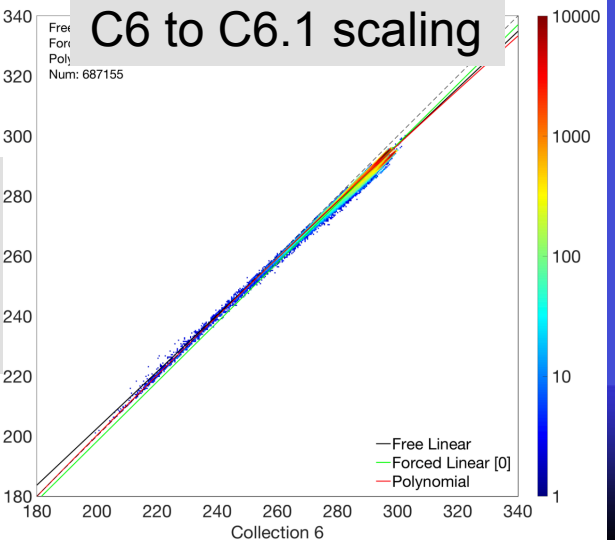
C6-C6.1

C6 to C6.1 scaling



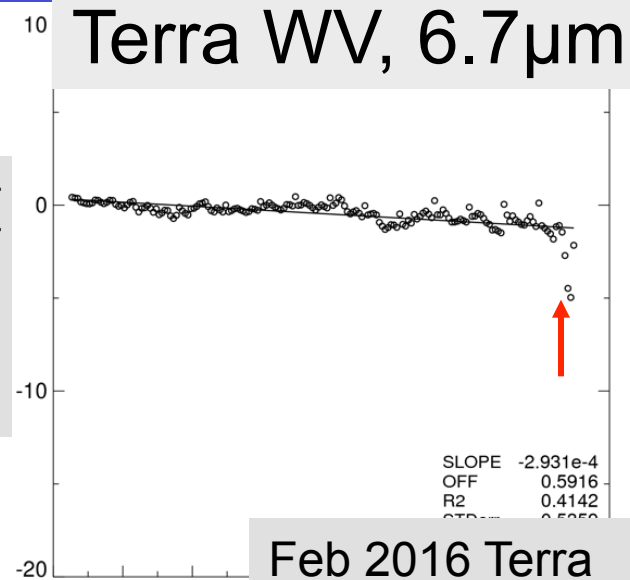
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C6.1 BT



C5

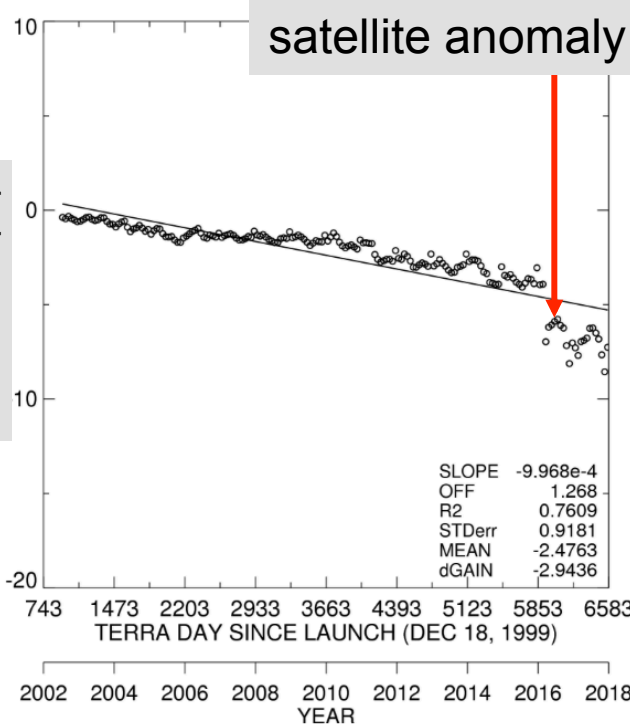
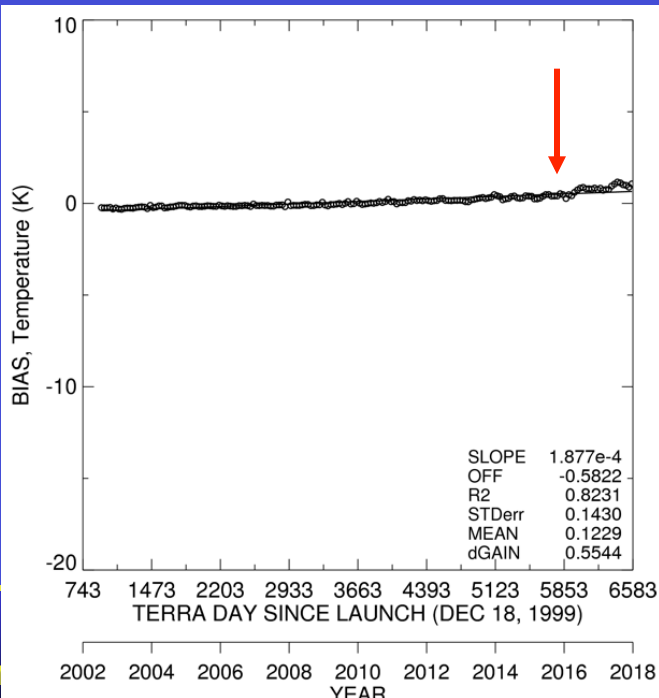
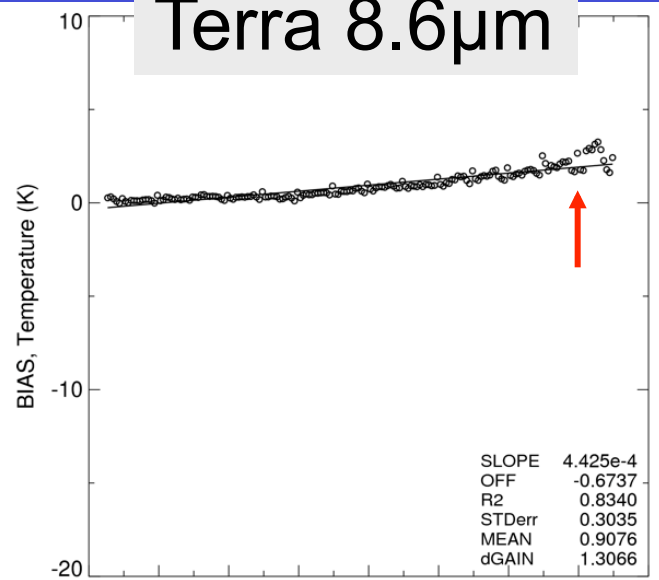
BT bias (K)

Terra WV, 6.7 $\mu$ m

Feb 2016 Terra satellite anomaly

C6

BT bias (K)

Terra 8.6 $\mu$ m

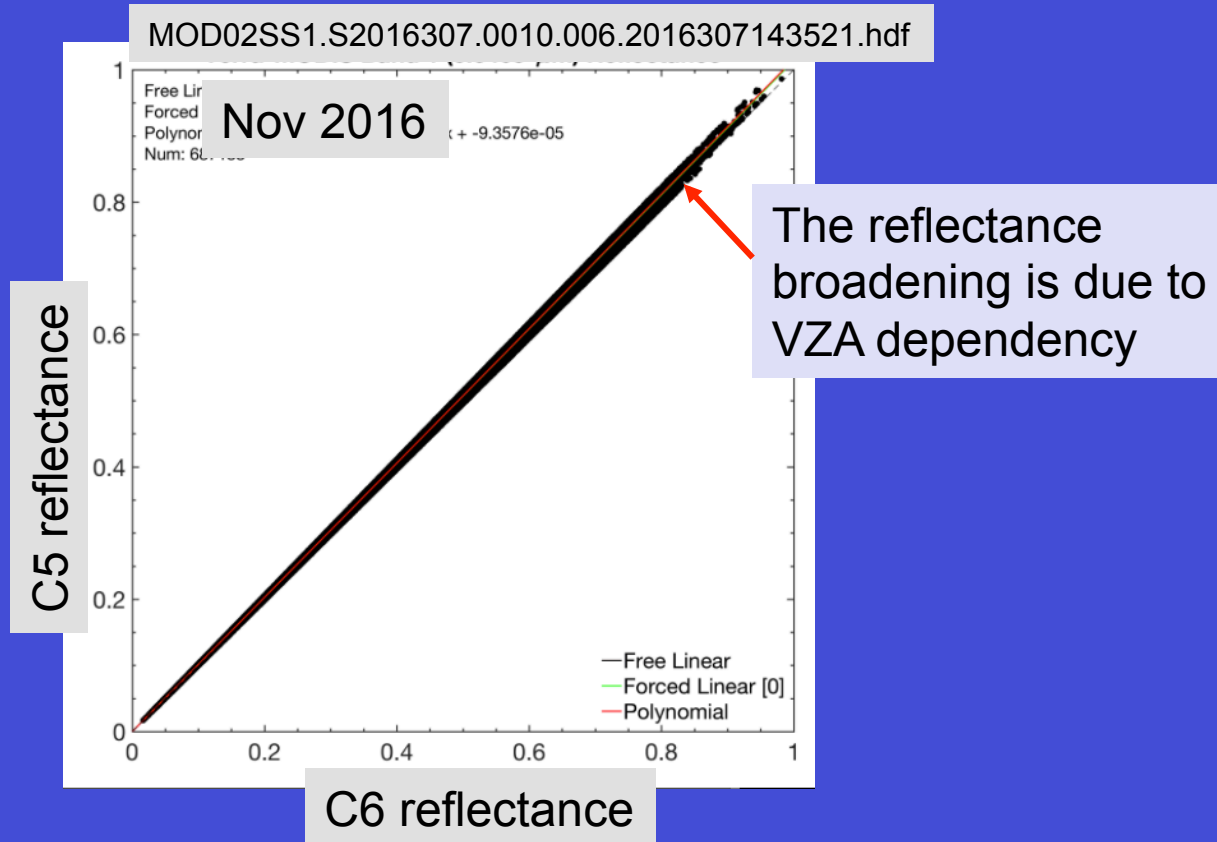
## Terra-Aqua BT bias

- The Terra-MODIS 6.7 $\mu$ m and 8.6 $\mu$ m are impacted by cross-talk, especially after the Terra spacecraft anomaly in late Feb 2016
- The cross talk started impacting cloud properties after 2010

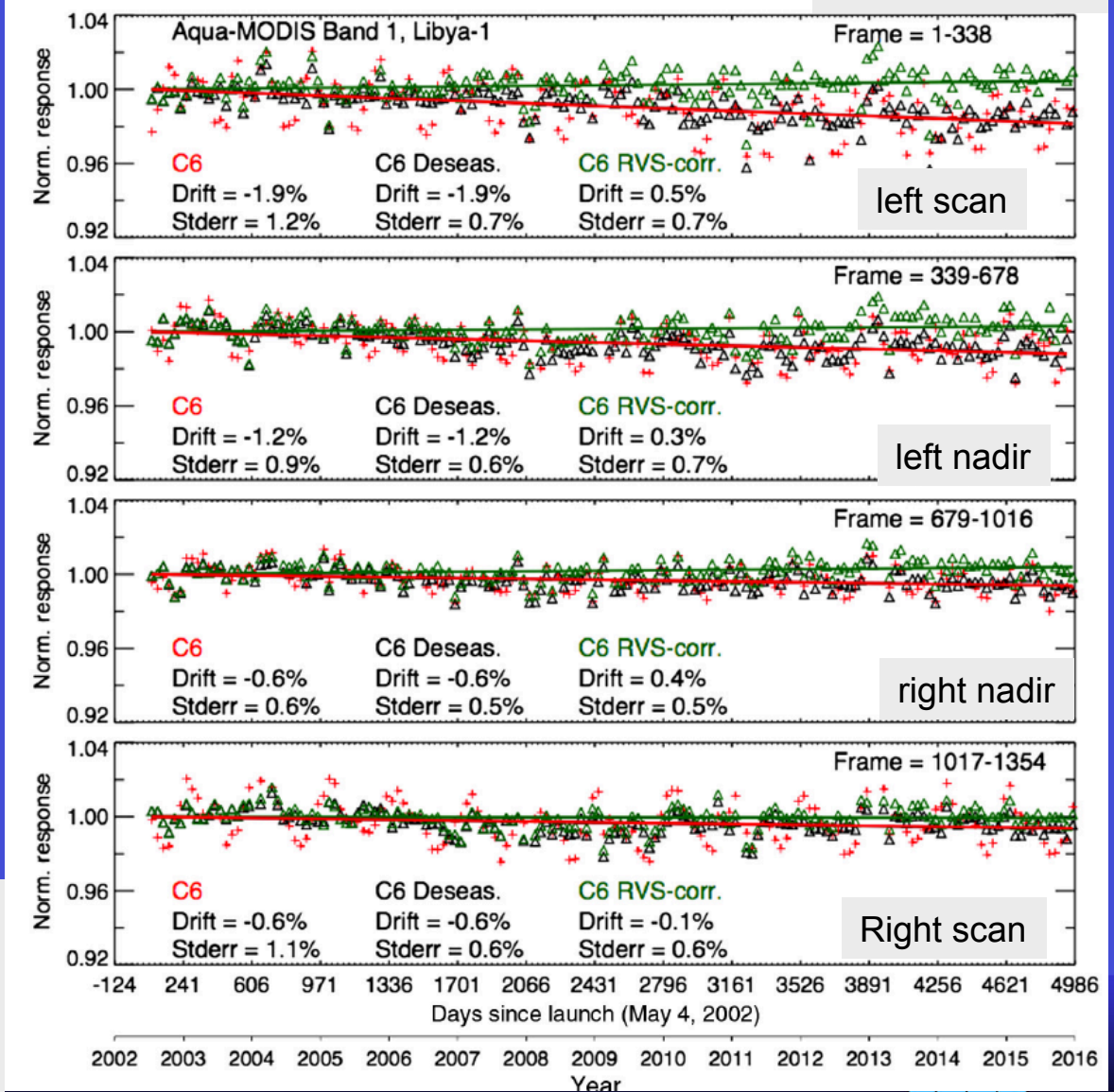


# Terra-MODIS 0.65 $\mu$ m, VZA reflectance dependency

Bhatt et al. 2017

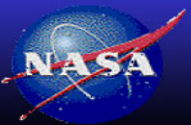


- The C5 residual azimuthal scan angle dependency between left and right of nadir is 0.5 to 1.0%
- This is confirmed using the Libya-4 invariant target, C6
- RVS corrections were based on the DCC mode method



# MODIS TO VIIRS SCALING FACTORS

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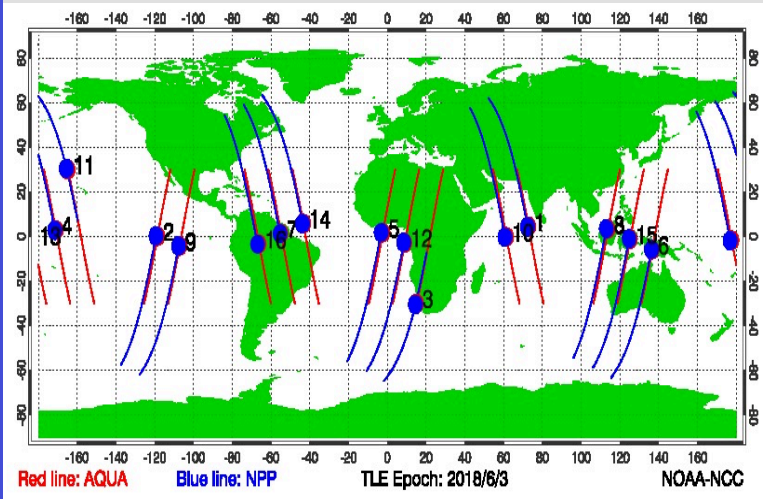
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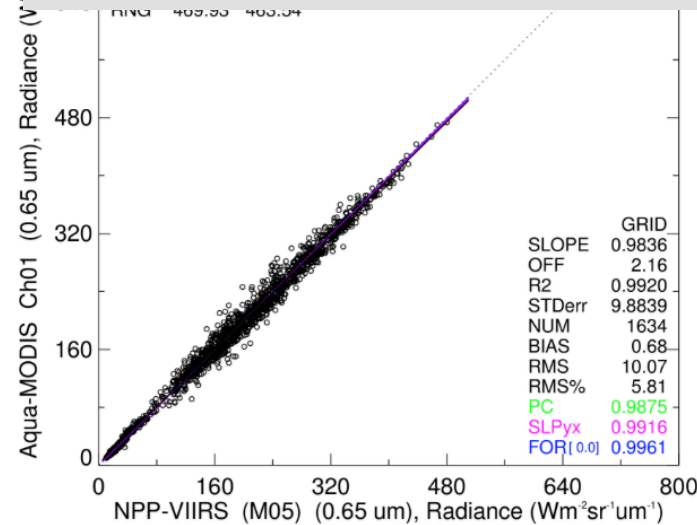


# Aqua-MODIS C6.1 and NPP-VIIRS V001 scaling

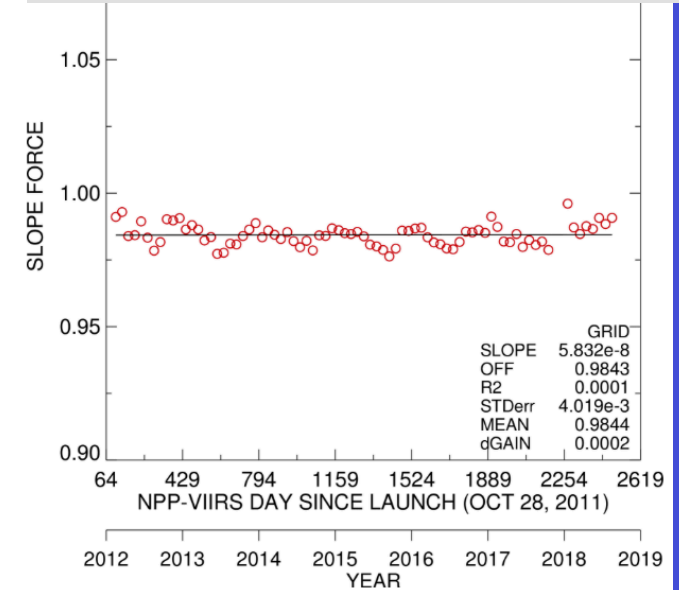
Aqua and NPP SNOs, June 3, 2018



Aqua C6.1 and NPP M5 V001, Jan 2018

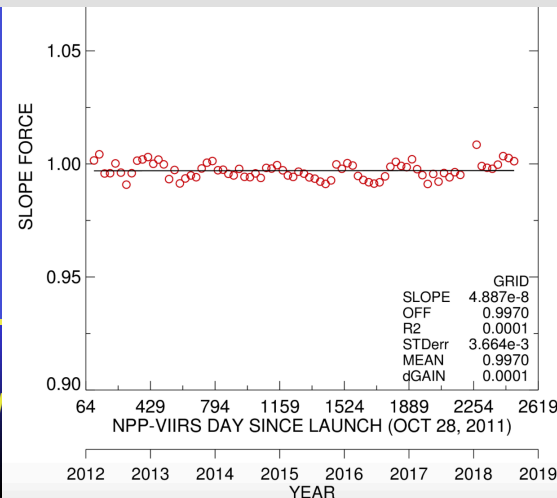


Aqua C6.1 and NPP M5 V001



Visible (%)	C6.1/V001
B3 0.47μm	-0.7
B1/I1 0.65μm	-0.3
B1/I1 0.65μm	-1.6
B2 0.86μm	-0.3
B5 1.24μm	1.2
B26 1.38μm	-2.9
B6/M10 1.61μm	-2.5

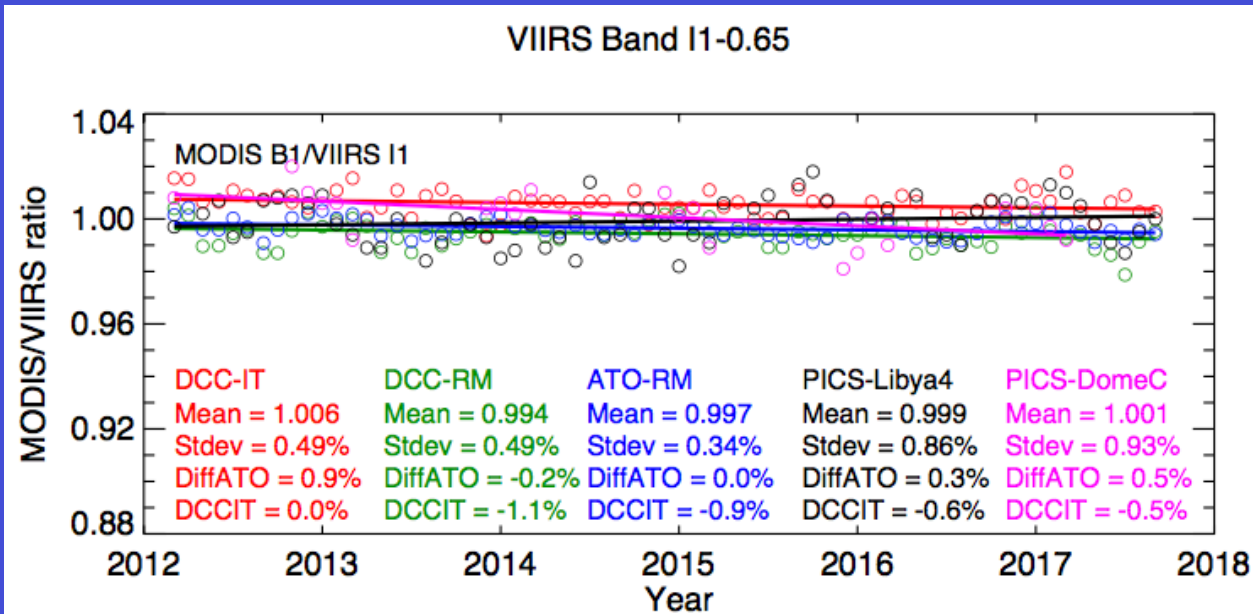
Aqua C6.1 and NPP I1 V001



- CERES using the I1 and not the M5 for VIIRS cloud retrievals
- Both I1 and M5 are based on the same solar diffuser for absolute calibration

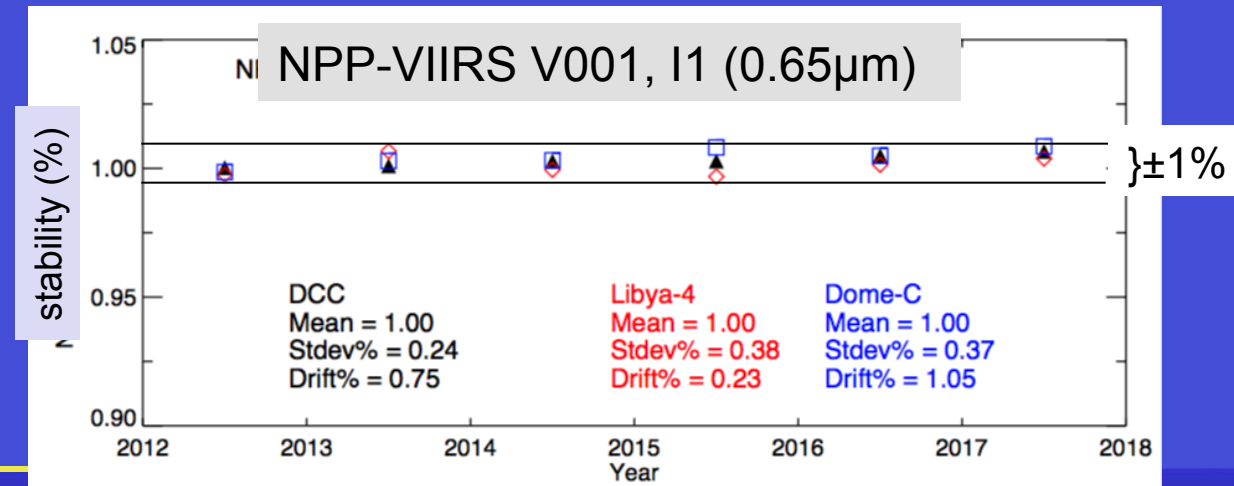
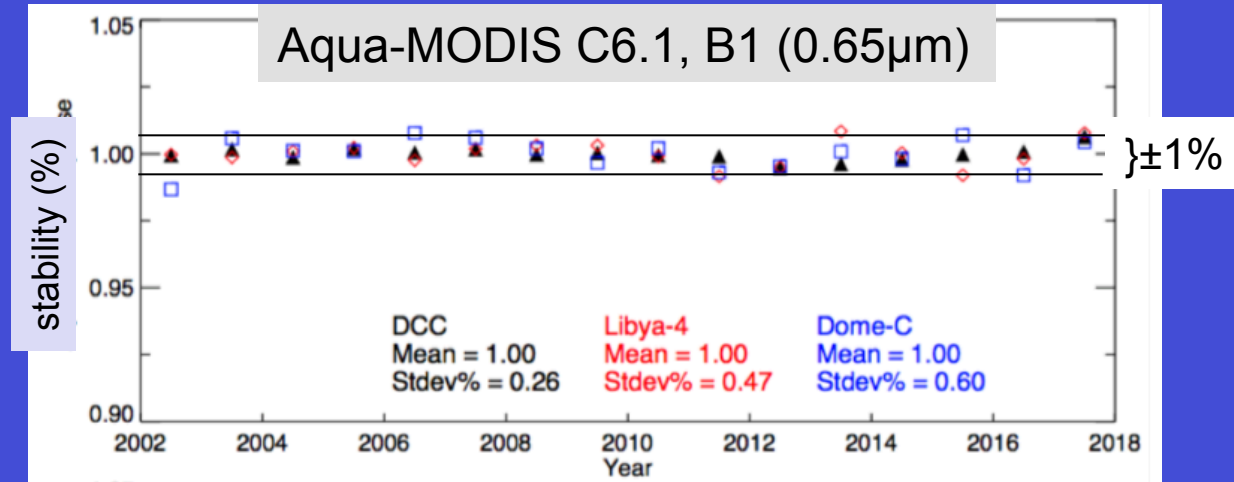


# Aqua-MODIS C6.1 and NPP-VIIRS V001 stability



- All 5 AQUA C6.1/NPP V1 inter-calibration methods are within 1%
- NOAA-20 VIIRS visible channels are 2% darker than NPP
- MODIS, NPP-VIIRS and N20-VIIRS all use different solar spectra

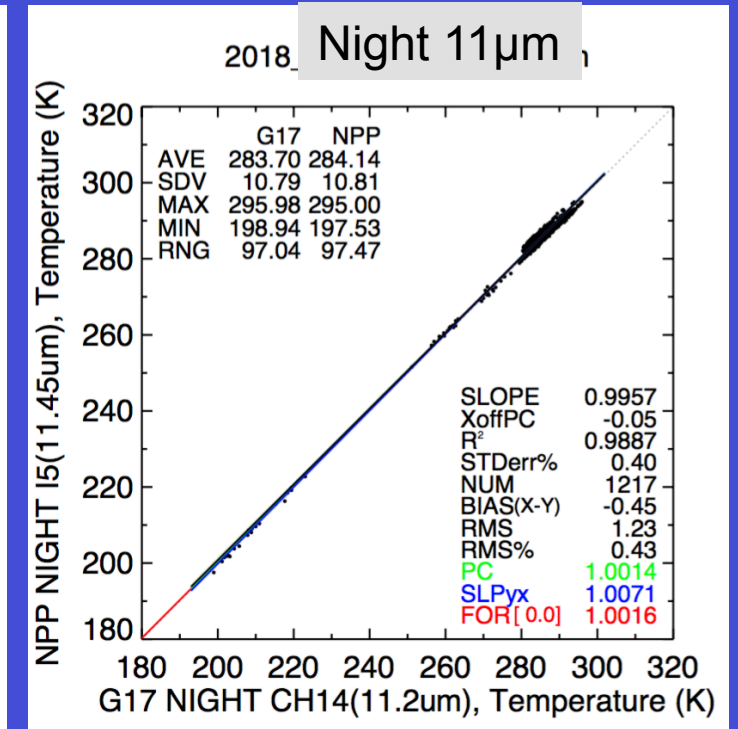
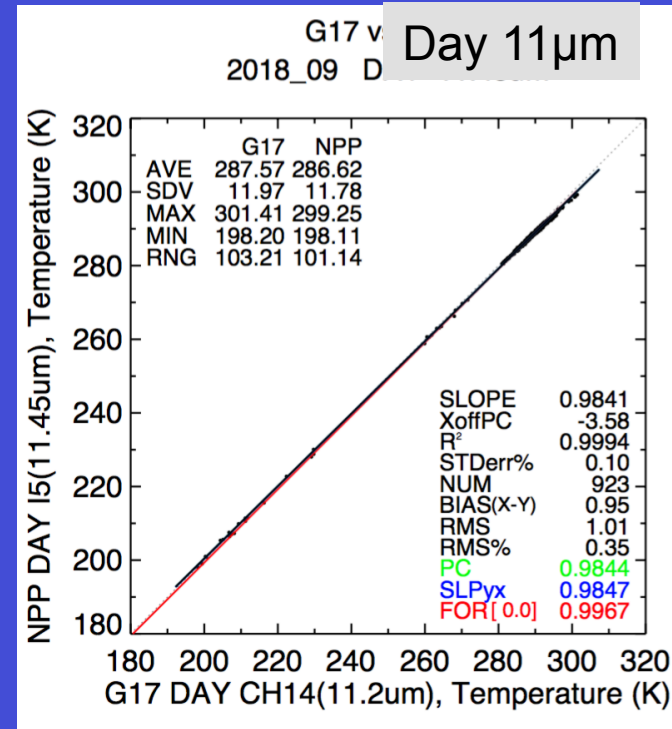
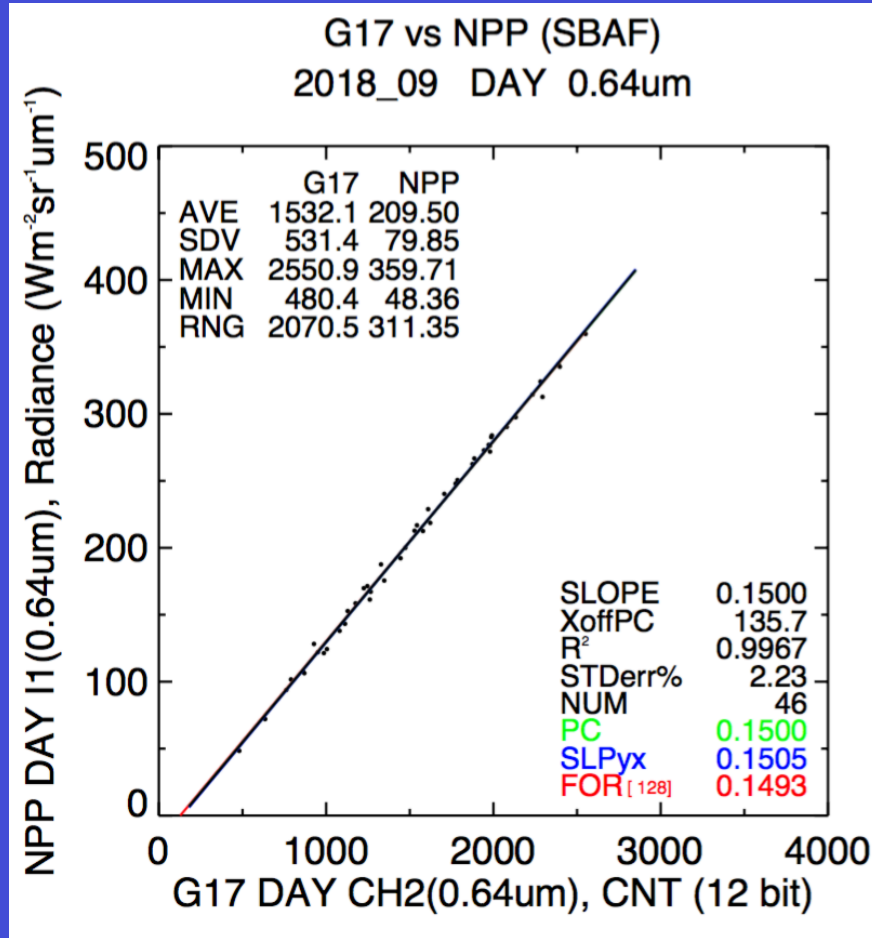
- We track the MODIS and VIIRS stability annually. Only want to correct the calibration drifts that are greater than 1%



NPP-VIIRS V1 I1(0.65 $\mu$ m) band, seems to have a calibration drift of 0.75%/6years



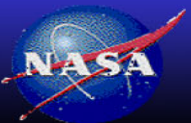
# Preliminary GOES-17/NPP-VIIRS V1, Sept 2017, inter-calibration



- GOES-17 is now ingested in McIDAS operationally, since August 28, 2018
- GOES-17 is located at the 105 East longitude position, should be operationally in late 2018
- GOES-17 cryogenic cooling not working, IR channels impacted during a few hours

# AEROSOL QUALITY BETWEEN C5 AND C6

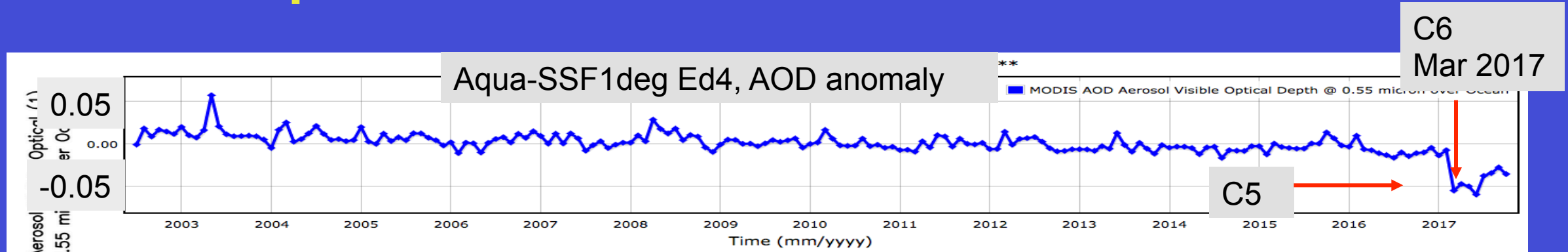
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# Aqua-MODIS Aerosol data from C5 to C6



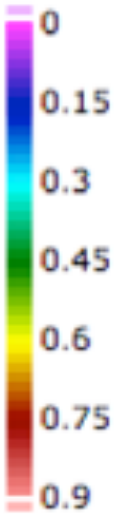
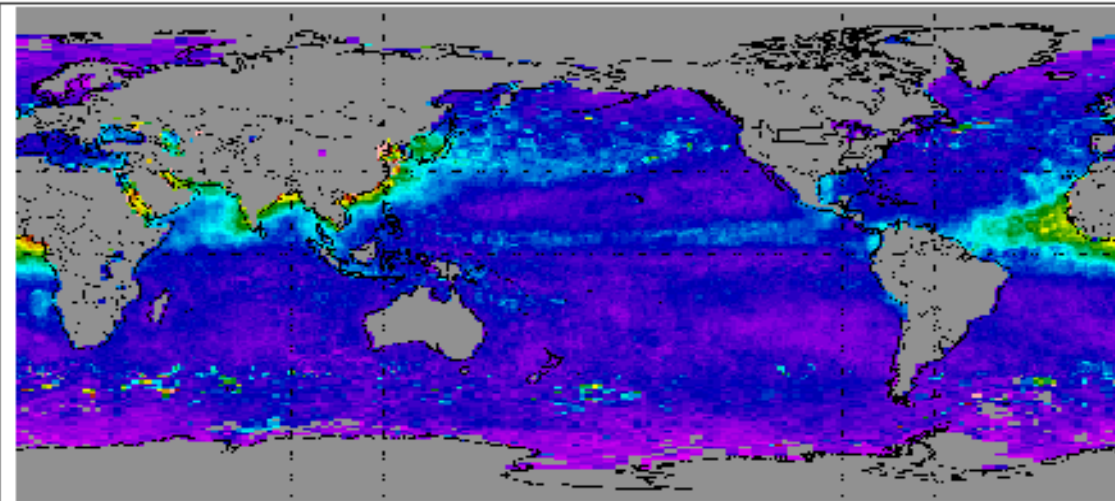
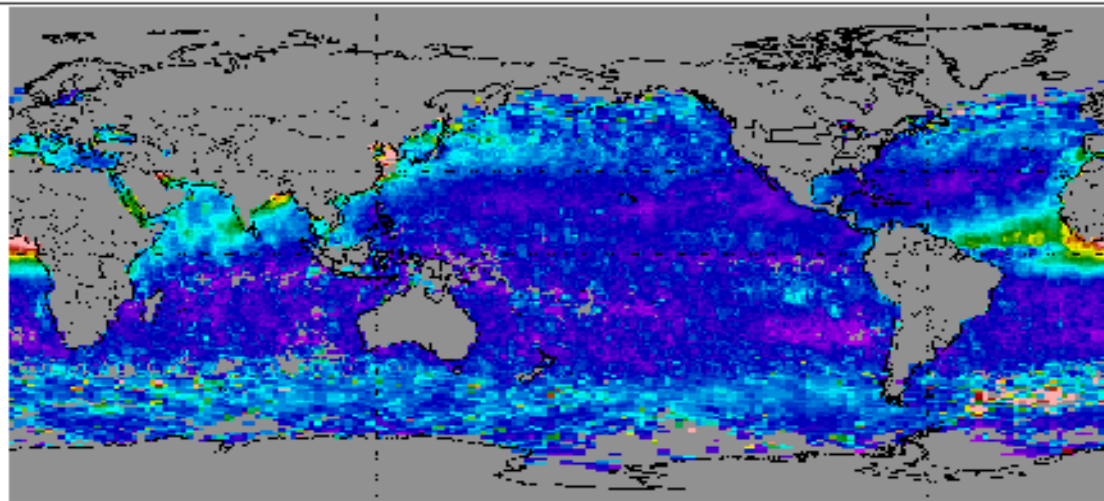
C5

February - 2017

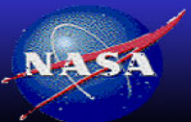
C6

March - 2017

AOD



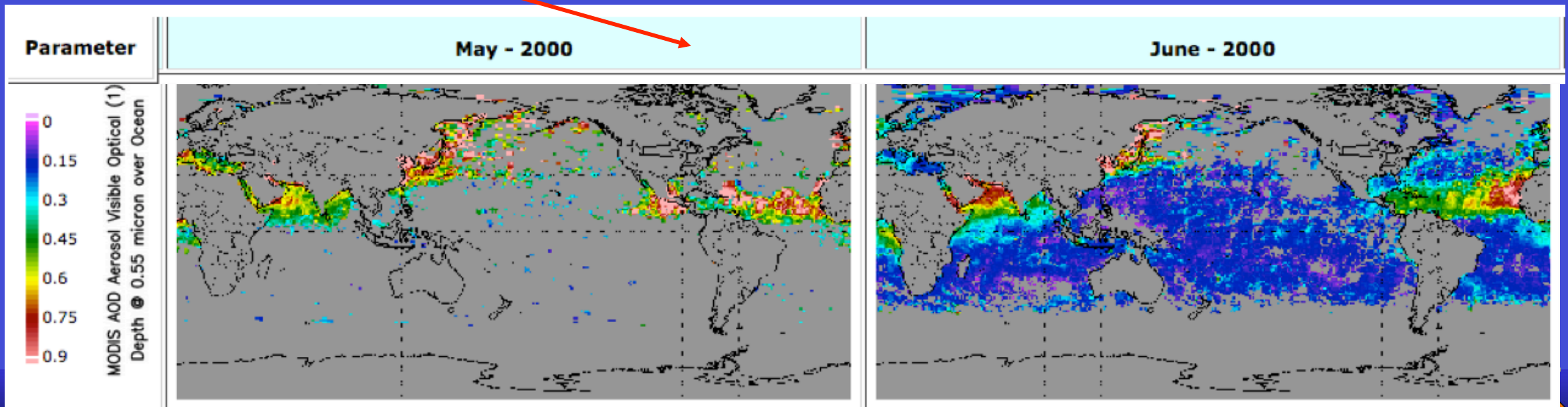
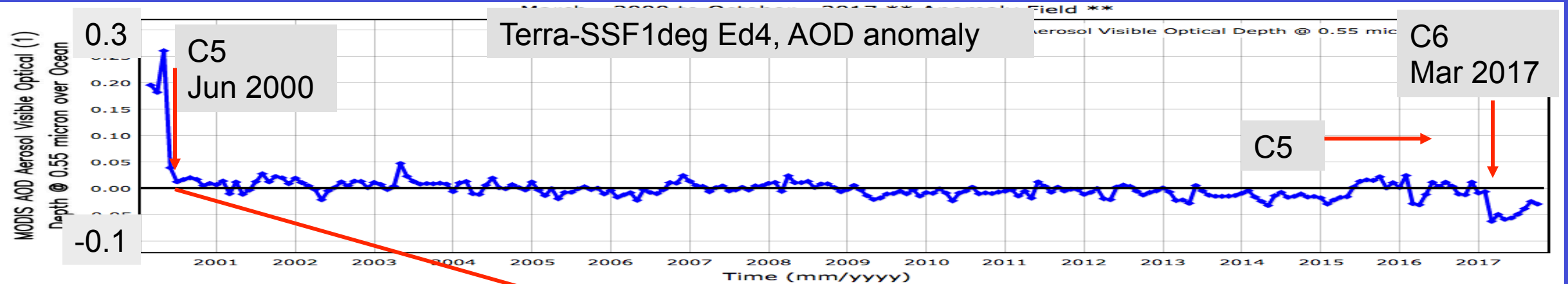
Decrease in AOD in southern ocean from C5 to C6



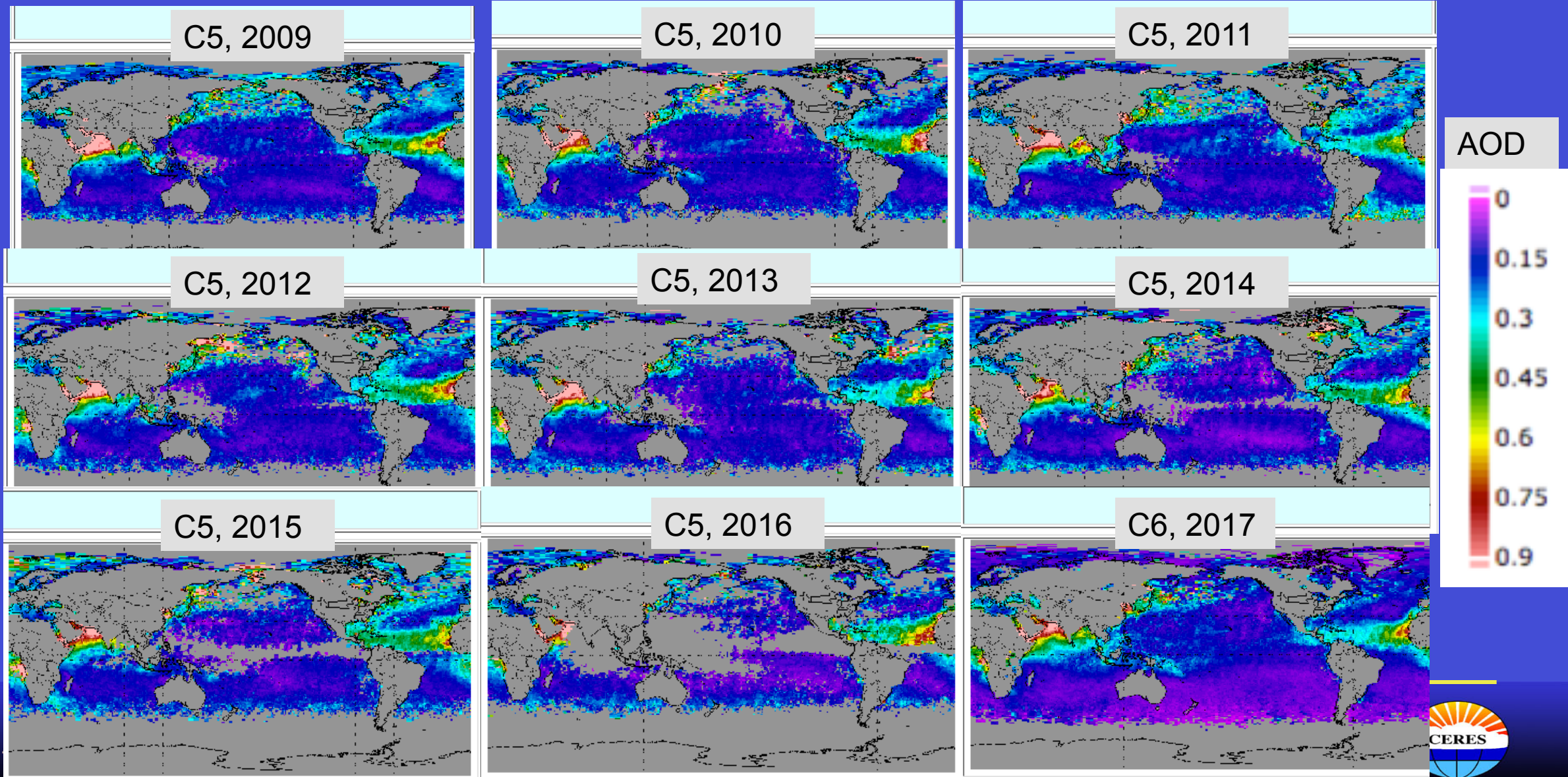
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# Terra-MODIS Aerosol data from C5 to C6



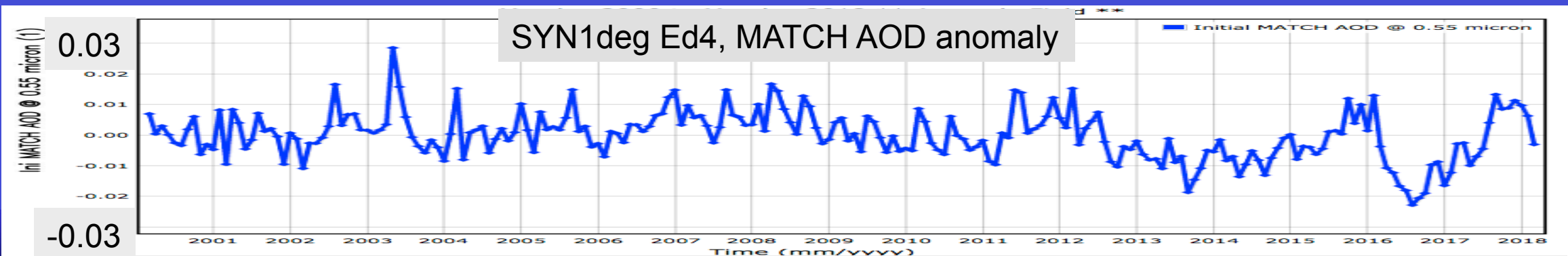
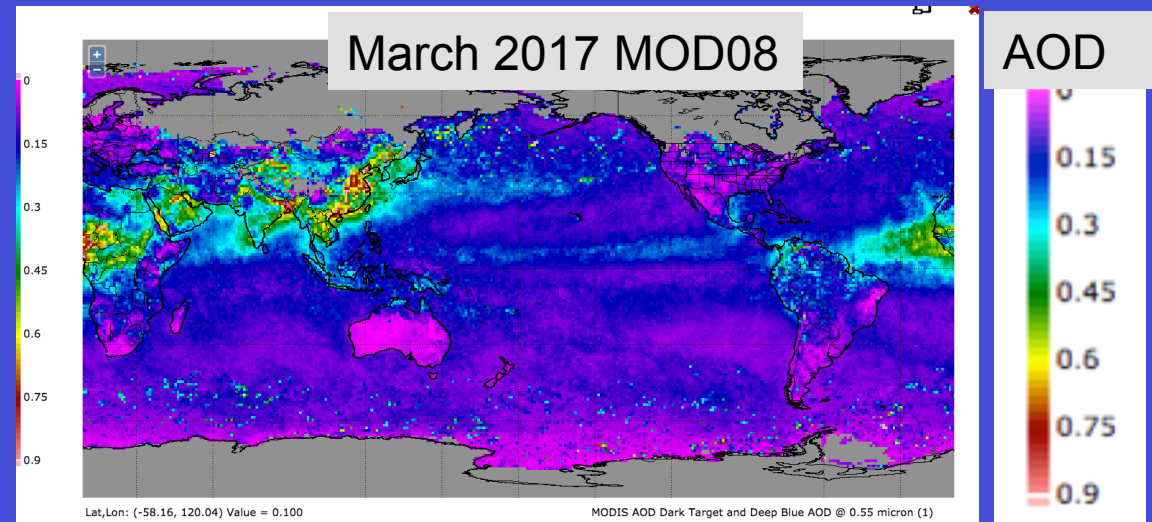
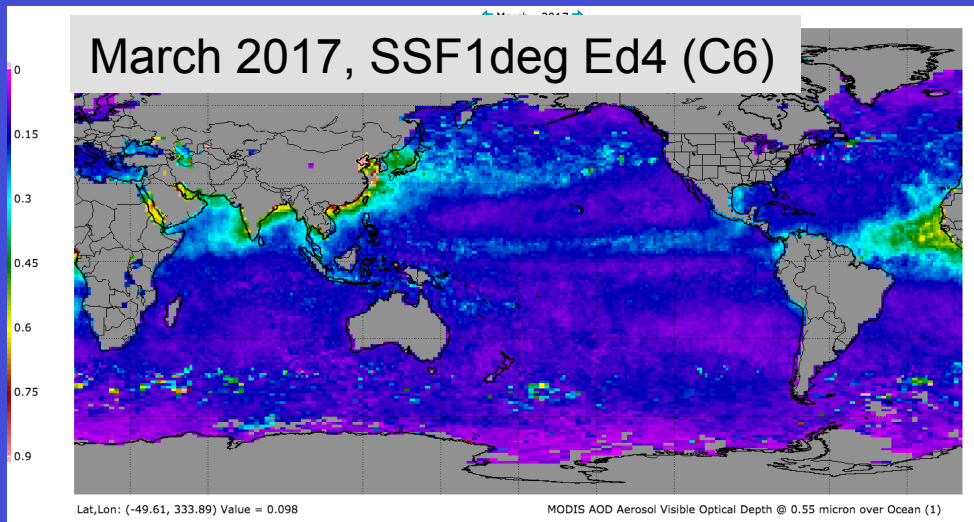
# Terra-MODIS Aerosol data, July 2009 to July 2017





# MODIS Aerosol Data

- Use the MOD08\_M3\_V6 product for combined dark target and deep blue to update SSF1deg-month, will implement for Ed4.1



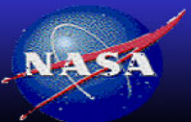
- Match Ed4 aerosol optical depth does not seem to be impacted as much



# SSF1deg product processing strategy

SSF1deg	March 2000...	July 2015	March 2016	March 2017	March 2018	April 2018 on
Ed4.0	C5			C6		Stops here
Ed4.1	C5		C6.1			

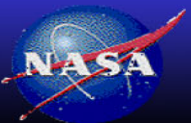
- MODIS C5 used from March 2000 to February 2017
- GSFC no longer processed C5 after March 2016, The Terra-SSF C6 cloud code did not use the WV and 8.6 $\mu$ m, due to the effects of cross-talk
- GSFC no longer processed C6 after March 2017, The Terra-SSF C6.1 cloud code reverted back to using the WV and 8.6 $\mu$ m, C6.1 mitigated cross-talk
- The SSF data has been reprocessed from March 2016 using C6.1 and is in forward processing mode.





# GEO PROCESSING IMPROVEMENTS

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# GEO processing strategy

SSF1deg	March 2000...	July 2015	March 2016	March 2017	March 2018	April 2018 on
Ed4.0	C5			C6		Stops here
Ed4.1 MODIS	C5		C6.1			
Ed4.1 GEO	C5	C6.1				

- Since the SSF1deg was going to be reprocessed for Ed4.1, presented the opportunity for the Himawari-8 and GOES-16 records to be reprocessed
- Unlike the other GEOs, the Him-8 and GOES-16 use MATCH aerosol input
- Usually GEO cloud properties cannot be reprocessed, since the EBAF-surface flux record relies on the SYN1deg surface fluxes to tune
- For Ed4.1 SYN1 will be reprocessed from the beginning of record to take advantage of a consistent MATCH dataset
- Since the Ed4 Him-8 and GOES-16 had many processing issues, and to make the codes more consistent, it was decided to reprocess (Him-8 from July 2015, and GOES-16 from Jan 2018)



# Himawari-8 processing events

- Snow/Ice Maps
  - Between July 2015 and Aug 2016 CERES snow/ice maps were not used and could have had missing days, clouds were retrieved as if no snow were present.
  - Between Sept 2016 and Dec 2017, CERES snow/ice maps were used. However, the daily snow maps used were 7 days in the future
- Imager Channel alignment
  - Misalignment between the 0.65 $\mu$ m (0.5km nominal) and the other channels was discovered in Aug 2017 due to a typo in the McIDAS IMGCOPY command
  - McIDAS software update improved the overall 16 channel alignment in Aug 2017, impossible to reproduce clouds before Aug 2017
  - Image misalignment results in an increase in pixel no retrievals
- MATCH aerosols
  - Between Sept 2016 and Jan 2017, the MATCH data was not in the archive. The code ran with the default aerosol flag. Updated for the full parameter products but not for EBAF.
  - Between July 2015 to Mar 2018, MATCH data was not read in for GMT=23 due to an indexing bug

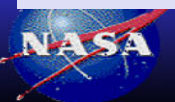


# Himawari-8, GOES-16 and future satellite code delivery improvements

- Background
  - The first delivery of the CERES Him-8 cloud codes was simply a wrapper around the Him-8 real-time code. There is only one version of the code that is used for both
  - The real-time had many input paths in case of missing inputs
  - The wrapper was simply relinking the input paths
  - Since the code ran could run without CERES inputs, processing traceability was impossible
- Ed4.1 delivery
  - The GEO code now requires a process control file (PCF). All input files are now managed outside of the cloud code. PCF files are archived for traceability
  - The GEO code stops if any input file is missing
  - The GEO code is now delivered and is compiled in processing environment and code archived
  - The Him-8 and GOES-16 clouds are now consistent
- Future GEO deliveries
  - Will require a version controlled and managed in bitbucket delivery so that science improvements are now traceable

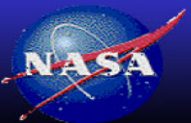
# CERES forward processing

- The 5 current GEO pixel level cloud properties are processed
- Automated GEO image anomalous detection program run, flagged images are visually examined and removed if necessary
- GEO pixel level radiances and clouds are regionally averaged and reexamined
- After the CERES instrument calibration and spectral response functions are determined (3 months after real-time)
- The subsetted SSF L2 Ed4 and GGEO gridded data are used to generate SSF1deg-lite and SYN1deg-lite are run for n and n-1 months
- Lite products are examined for temporal consistency
- EBAF-TOA is then processed and approved for n and n-1 months, 4 to 6 months behind realtime
- GEO pixel level and regional gridded files are archived at the DAAC
- SYN1deg and SSF1deg-full parameter is processed usually one month behind EBAF-TOA, since the next day of the following month is necessary to process
- EBAF-surface is processed usually in 6 month intervals.



# ED4 AND ED4.1 TOA FLUX COMPARISONS

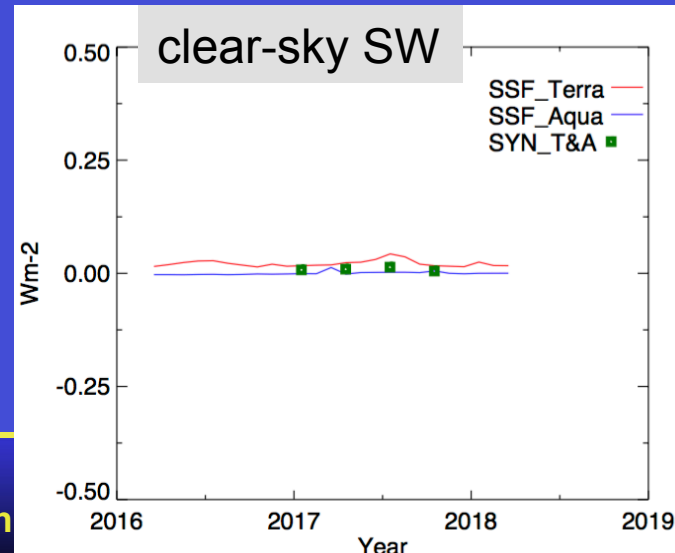
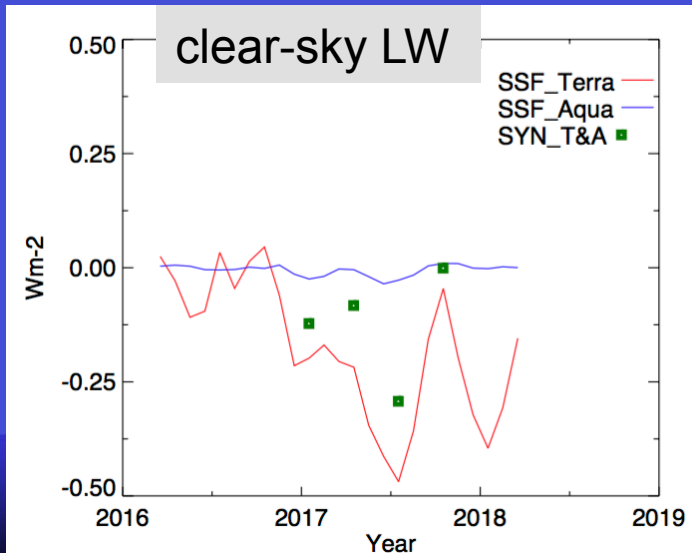
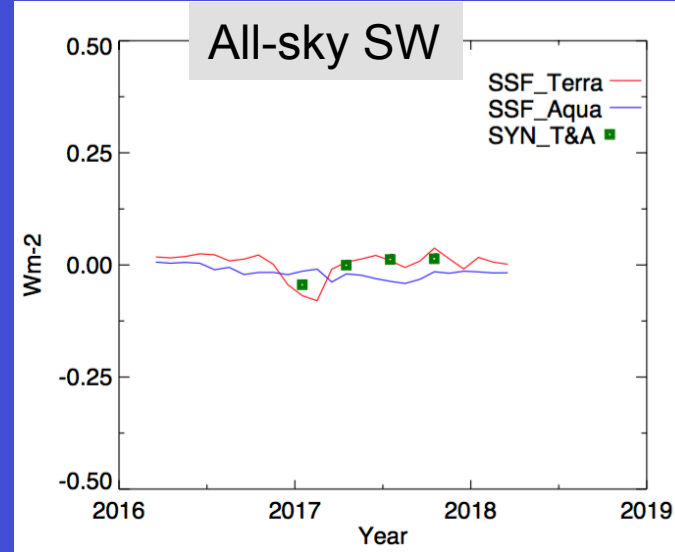
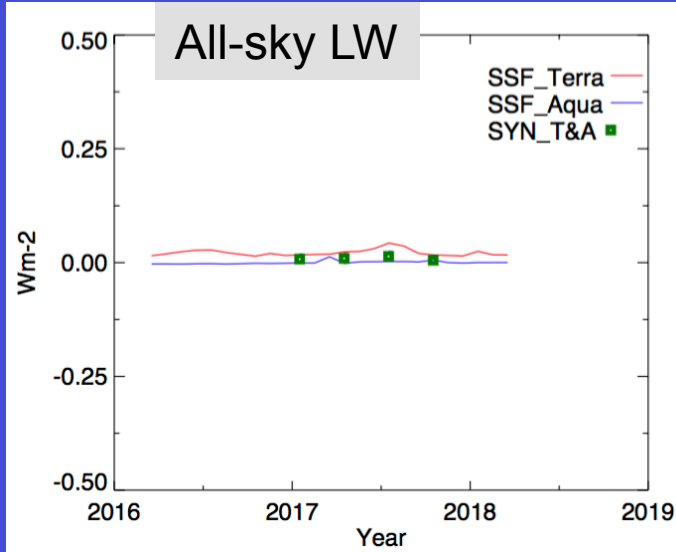
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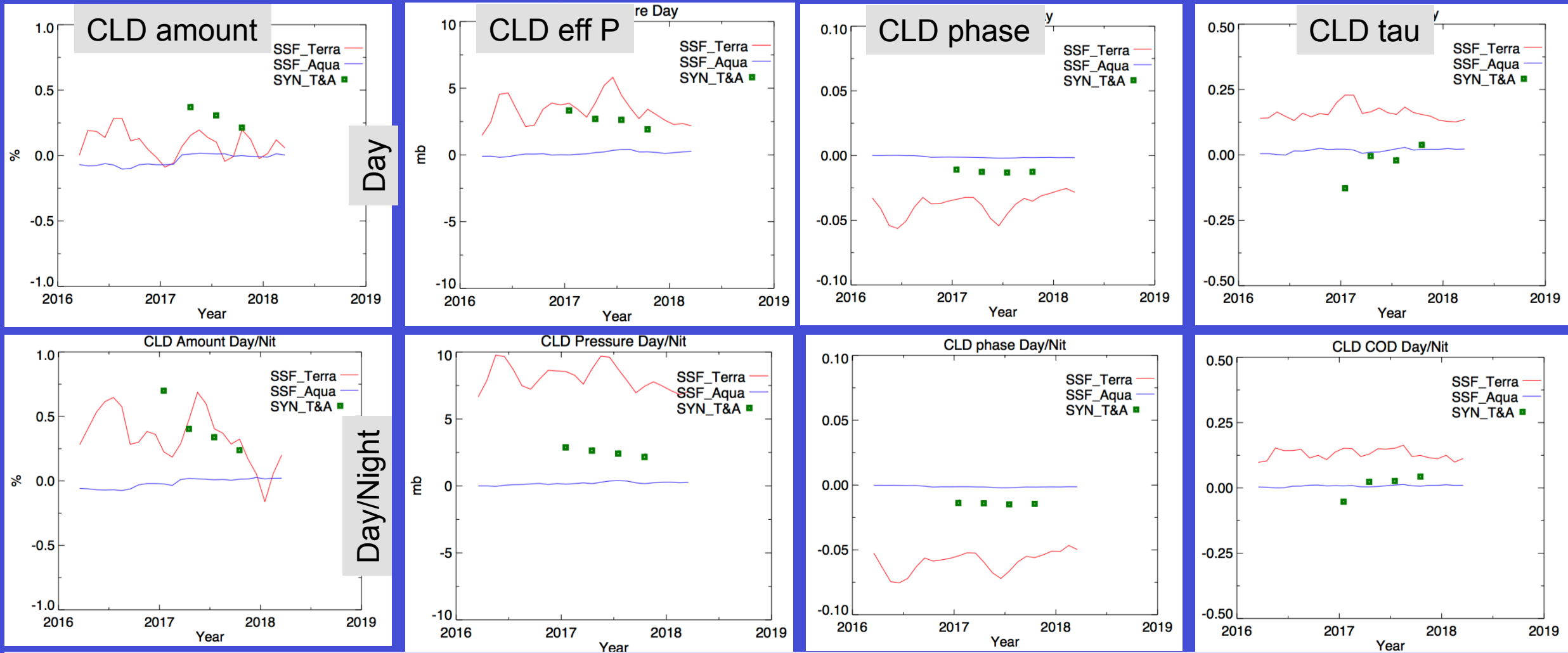
# Ed4.1 – Ed4.0 SSF1deg-lite global fluxes



- The SSF L2, SSF1deg, SSF1deg-lite were with MODIS C6.1 between March 2016 to March 2018 as Ed4.1 and compared with the Ed4, which used C5 until Feb 2016, and C6 until Mar 2018.
- The SYN1deg-lite Ed4.1 was run for 4 test months for Jan, Apr, Jul, and Oct 2017
- The lite products are used to generate the EBAF fluxes

- The C5 and C6 have clouds and clear-sky fraction that differ from C6.1, which could impact the TOA fluxes
- The global mean fluxes barely changed.

# Ed4.1 – Ed4.0 SSF/SYN1deg-lite cloud properties



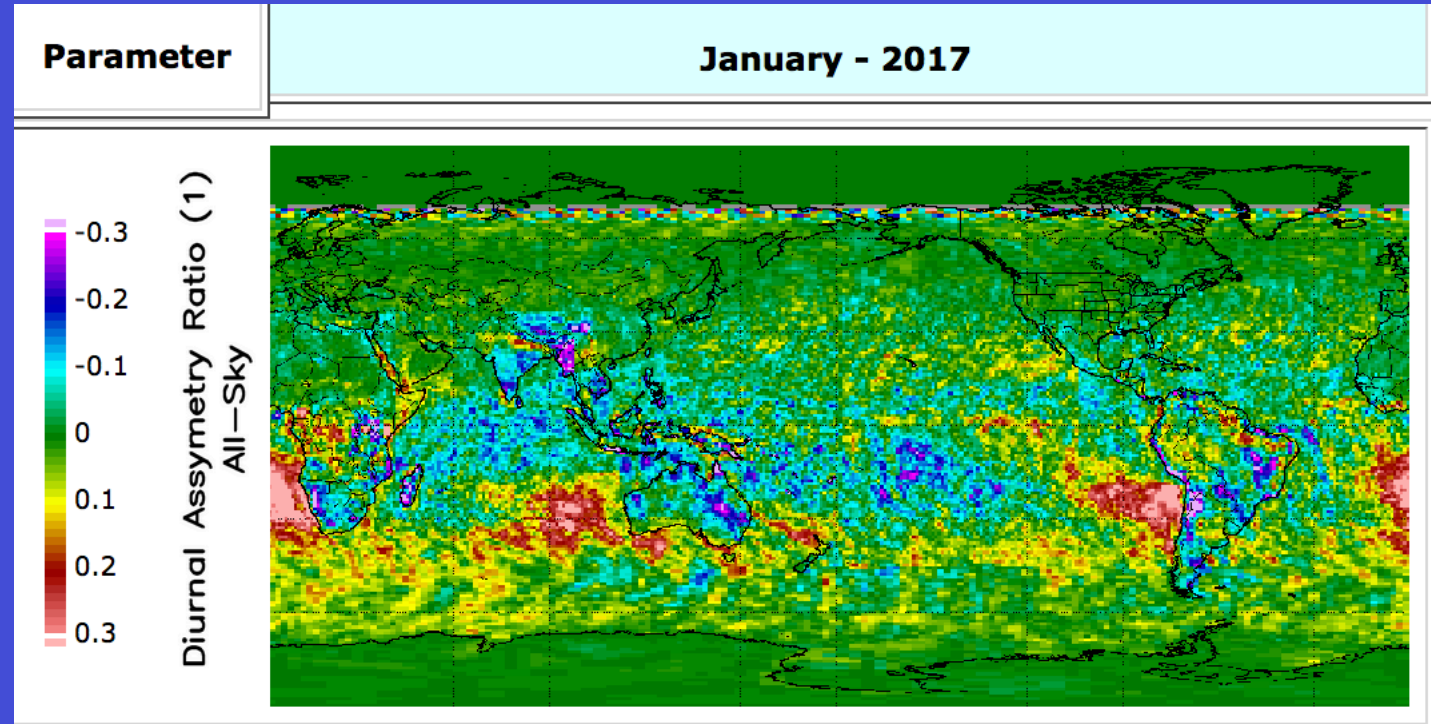
- Aqua-MODIS does not have WV and 8.6 $\mu$ m cross-talk.
- The global mean clouds did not change much. It is interesting the the cloud amount and tau both increased



# Diurnal Asymmetry Ratio (DAR)

$$\text{DAR} = \frac{F^{\text{SW}}(\text{morn}) - F^{\text{SW}}(\text{aft})}{F^{\text{SW}}(24 \text{ h})},$$

- DAR is positive if there are more clouds in the morning (stratus regions), and negative if there are more clouds in the afternoon (land convective regions)



- EBAF takes into account the regional diurnal SW all-sky flux, by comparing the SSF1deg DAR with the SYN1deg DAR, and adjusting the SSF1deg SW flux accordingly.
- The regional diurnal LW all-sky flux, simply uses the SYN1deg flux.
- The GEO derived fluxes are regionally normalized at the Terra and Aqua measurement times to remove any algorithm inadequacies and are scaled to the CERES instrument calibration.
- If the GEO hourly clouds change asymmetrically about noon could impact the EBAF SW fluxes.

# SYN1deg-lite Ed4.1 – Ed4 all-sky flux differences

Jan 2017

Apr 2017

Jul 2017

Oct 2017

All-sky SW  
 $\pm 3 \text{ Wm}^{-2}$

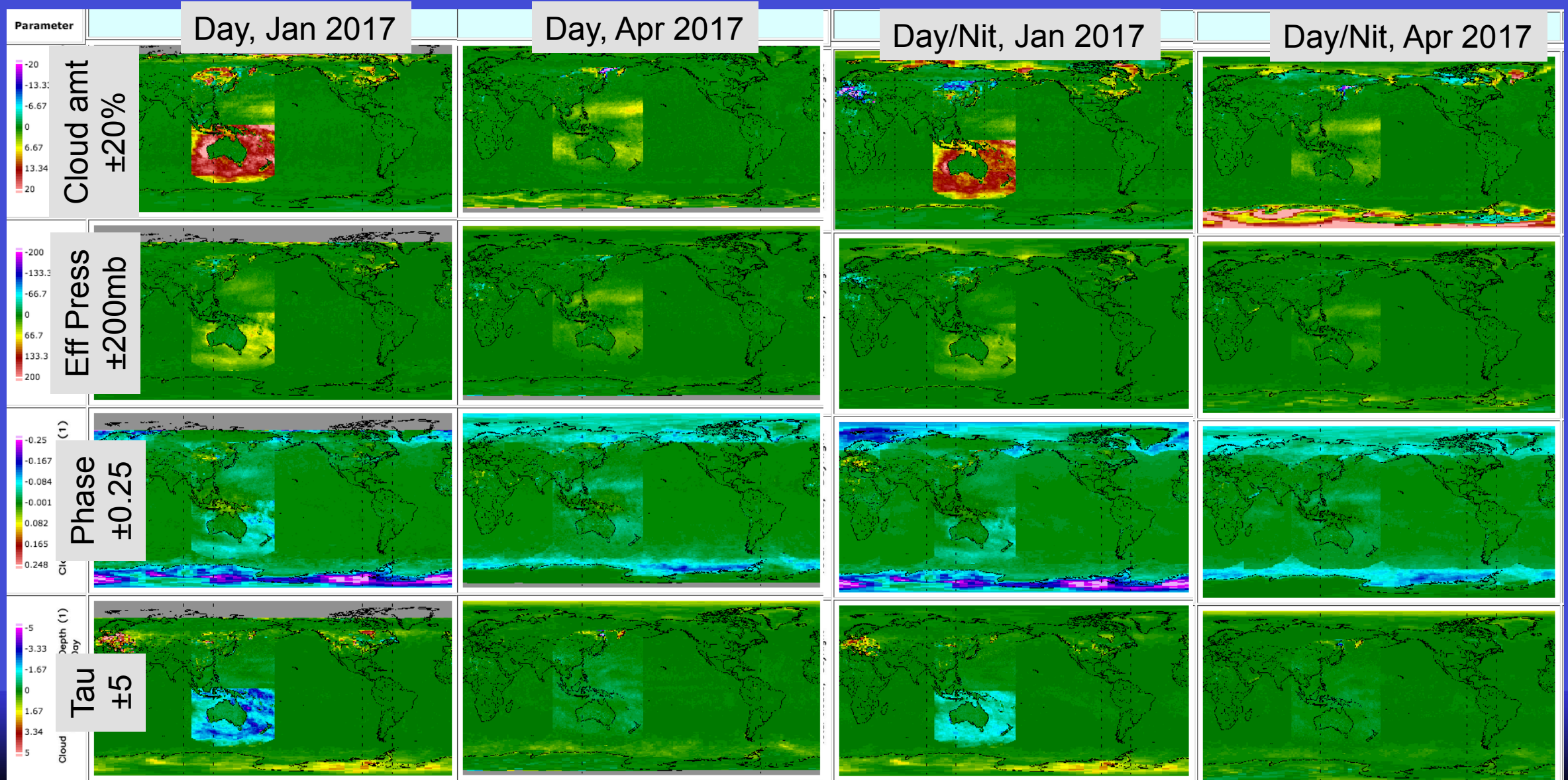
All-sky LW  
 $\pm 1 \text{ Wm}^{-2}$

DAR  
 $\pm 0.1$

- Other than Jan 2017, the Himawari-8 cloud property improvements did not impact the SW and LW fluxes or DAR. Jan 2017 Him-8 was run without MATCH and a default aerosol value was used.

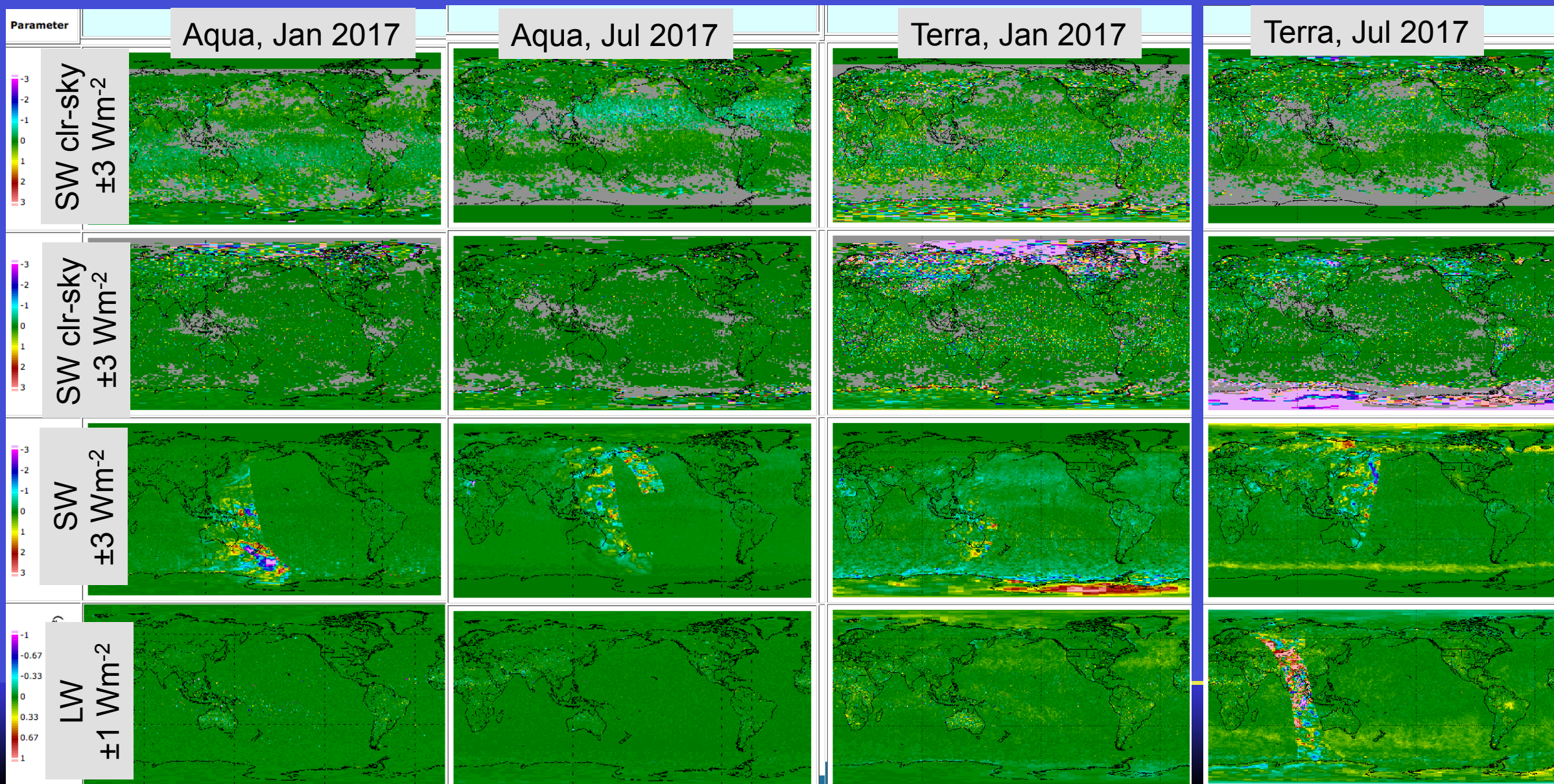


# SYN1deg-lite Ed4.1 – Ed4 cloud differences



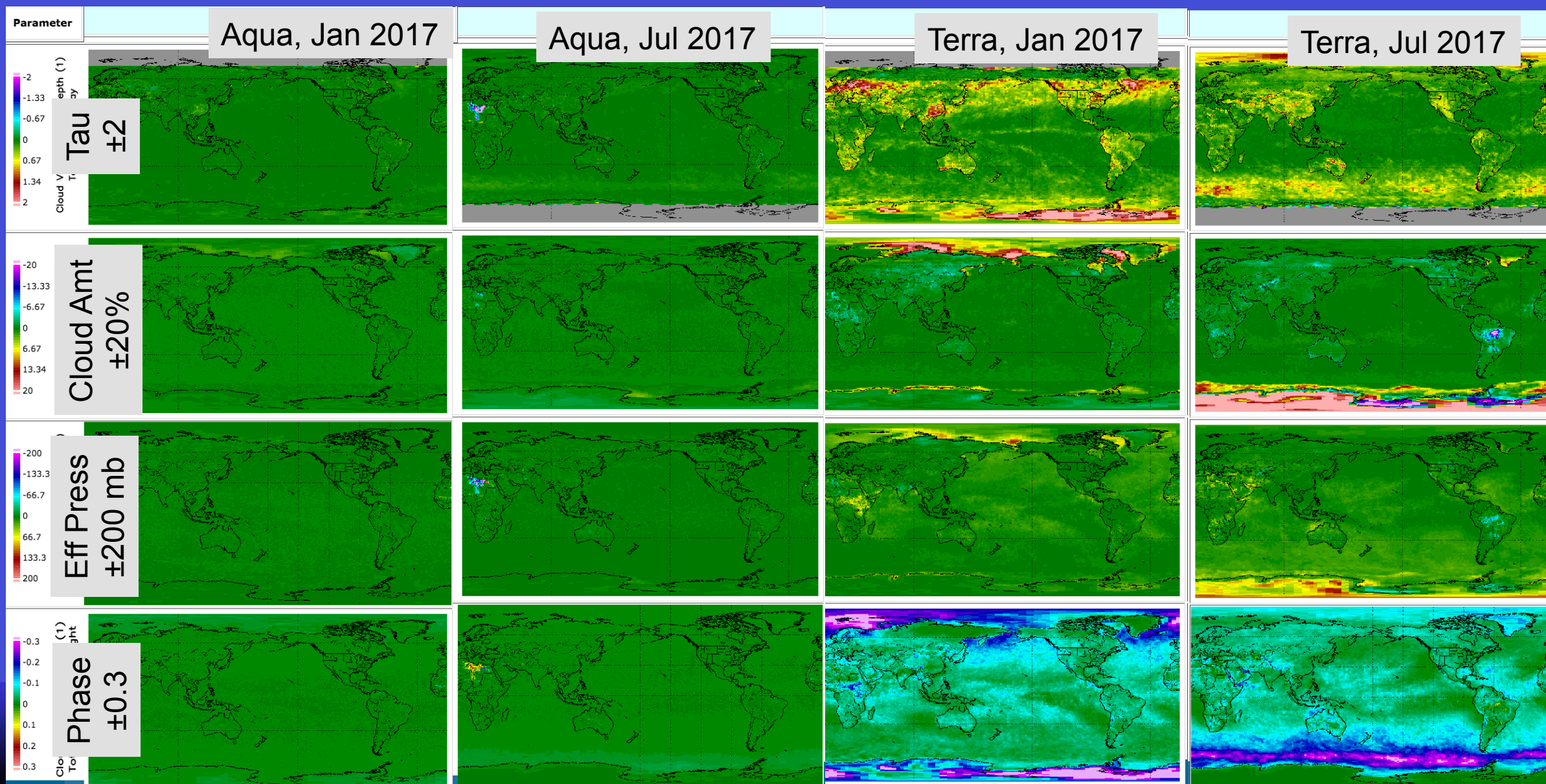


# SSF1deg-lite Ed4.1 – Ed4 TOA flux differences

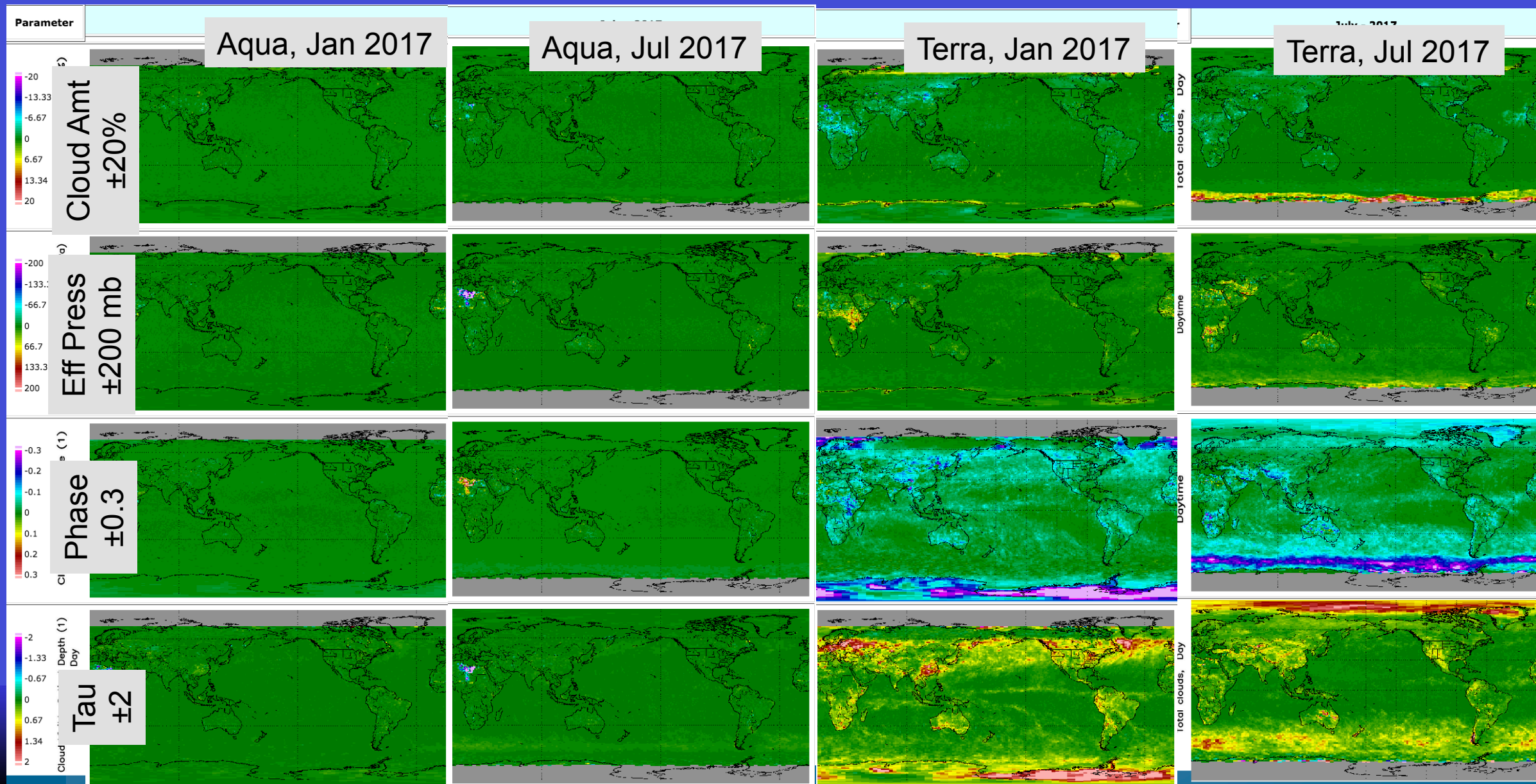




# Day/night SSF1deg-lite Ed4.1 – Ed4 cloud property differences



# Day-only SSF1deg-lite Ed4.1 – Ed4 cloud property differences





# EBAF-SFC and SYN1deg (SYNI) computed fluxes

EBAF-SFC	March 2000...	January 2008	July 2015	March 2016	March 2017	March 2018	April 2018 on
Ed4.0							
MODIS	C5				C6		
GGEO	C5				C6		
MATCH	C5				C6		
Land BRDF	C5				C6		
Ed4.1							
MODIS	C5			C6.1			
GGEO	C5		C6.1				
MATCH	C6.1						
Land BRDF	C6	C6.1		C6.1			

- EBAF surface and SYN1deg Ed4.1 is expected to be released in March 2019
- Only the surface fluxes will be updated in SYN1deg Ed4.1

# Conclusions

- The MODIS collection and aerosol version improvements prompted Ed4.1 reprocessing
  - The Terra WV and 8.6 $\mu$ m spacecraft anomaly induced cross-talk mitigated
  - MODIS and MATCH aerosol record now more consistent
  - The Him-8 and GOES-16 processing now made more traceable and greater consistency with MODIS clouds
- CERES Products
  - EBAF TOA fluxes did not change significantly between Ed4 and Ed4.1. Not reprocessed.
  - EBAF clouds, Terra and Aqua day/night clouds reprocessed from March 2016
  - SSF1deg TOA fluxes reprocessed from March 2016 completed and in forward processing mode
  - SYN1deg observed TOA fluxes, no change prior to July 2015. Him-8 and GOES-16 reprocessed from beginning of records. Uses the SSF1deg from March 2016 reprocessed fluxes
  - EBAF-surface and SYN1deg computed fluxes, reprocessed from beginning of record, to be released in March 2019
- MODIS and VIIRS scaling
  - The NPP and N20 VIIRS cloud property retrievals to use imager radiances scaled to the MODIS C6.1 calibration to allow for consistent cloud retrievals between MODIS and VIIRS